AN ABSTRACT OF THE THESIS OF

J. Megan Irwin for the degree of Master of Science in Exercise & Sport Science presented on May 24, 2013
Title: Motor and Social Development: Differences between Children with and without Autism?

Abstract approved:

Megan MacDonald

Current prevalence statistics suggest 1 in 88 children are diagnosed with autism spectrum disorder (ASD) (CDC, 2012). ASDs are pervasive developmental disorders characterized by social communicative deficits and restricted interests and behaviors (APA, 2000). Children with ASD also display deficits in motor skills (Green et al., 2002: Pan, Tsai, & Chu, 2009; Provost et al., 2007). Prior research suggests that the developmental domains of cognition and language are related to both the motor and the social domains (Chen & French, 2008; Thelen, 2000). Yet there is a paucity of research examining the relationship of motor skills and social skills in young children with ASD. PURPOSE: The purpose of this study was to examine the relationship of social and motor skills in young children with autism. METHODS: The participants of this study included young children with and without ASD between the ages of 2-7 years old. All participants were administered The Mullen Scales of Early Learning (MSEL), a valid and reliable measure of development in young children, and the Peabody Developmental Motor Scales (2nd Ed.) (PDMS-2), which is a standardized tool to measure the motor skills in children up to 5 years of age. Raw scores for fine, gross, and total motor

components were used in data analysis of motor skills. Evaluations of social skills were assessed using the Autism Diagnostic Observation Schedule- calibrated severity scores (CSS) (Gotham et al., 2007; Gotham et al., 2009). RESULTS: As expected there were no statistical differences between groups for non-verbal IQ ($p = 0.49$). However, statistical differences did exist for social skills ($p < 0.01$) and motor skill ($p < 0.01$) between groups. All children with ASD scored lower than children without ASD on motor scores, however this difference was not statistically different. No correlations were found between motor and social skills within groups. However, a moderate relationship was seen between grasping motor skills and social skills ($r = -0.50$) when observing the total sample. CONCLUSION**:** While significance was not found in the difference of motor performance between groups, children with ASD scoring lower in each motor category supports the perspective that children with ASD, who by nature of the disorder, have lower performance of social skills also have lower performance of motor skills than their peers without ASD. Having a small sample and large variance in performance of motor skills in our participants may have contributed to the lack of relationship found between motor and social skills for both groups. Therefore, further investigations of the questions in this study using larger sample sizes need to be conducted.

Motor and Social Development: Differences between Children with and without Autism?

by
J. Megan Irwin

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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J. Megan Irwin, Author

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Motor and Social Development: Differences between Children with and without Autism?

Autism spectrum disorder (autism or ASD) is a pervasive developmental disorder characterized by social communicative deficits, restricted interests and repetitive behaviors (American Psychiatric Association [APA], 2000). Currently, 1 in 88 children in the United States are diagnosed with ASD (Center for Disease Control & Prevention [CDC], 2012). However, a recent survey suggests 1 in 50 children between the ages 6-17 years old have ASD according to parent-report (Blumberg et al., 2013). In addition to criterion stereotypic and repetitive motor behaviors, children with ASD also display deficits in gross and fine motor skills (Green, 2002; Miyahara, 1997; Ozonoff et al., 2008; Pan, Tsai, & Chu 2009; Provost, Lopez, & Heimerl, 2007; Staples & Reid, 2010). Although, there is no known cure for autism, there are a number of treatment options which include: speech therapy, occupational therapy, physical therapy, pharmacological therapy to help manage associated symptoms, and behavioral approaches to improve social and communication skills (Francis, 2005; Meyers & Johnson, 2007; Volkmar, Lord, Bailey, Schultz, & Klin, 2004).

The most widely recommended mode of treatment for this developmental disorder is early behavioral intervention (Kasari et al., 2005). This treatment strategy has been successful at improving autism symptomatology (Dawson et al., 2009; Kasari et al., 2005; Rogers & Vismara, 2008). Though a variety of different early intervention programs exist, early intervention primarily targets improving social communicative skills (e.g. imitation, joint interaction, eye contact, and play). On the contrary, although motor skill deficits in individuals with ASD are well documented, motor skill improvement is a somewhat neglected content area in early intervention treatments (Lloyd, MacDonald & Lord, 2013; Sutera et al., 2007). This lack of attention towards motor skill improvement is worrisome, particularly when considering the potential impact weak motor skill might have on other developmental domains. Developmental domains, such as cognition, language, and social are not always discrete from each other. Interaction of one domain with another is frequently discussed throughout developmental literature (Bishop & Norbury, 2005; Miller, 2002a; Miller, 2002b; Rubin, Fein, & Vandenberg, 1983). For instance, motor skill development contributes to other developmental outcomes for children such as cognition by providing the infant the ability to explore and learn about his environment and language by providing means for sound production and variation (Miller, 2002a; Miller, 2002b; Thelen, 2000). Additionally, language and cognitive development contribute to acquisition of social skills through the ability to communicate and understand the wants and needs of others as well as learn appropriate actions and responses in social settings (Chen & French, 2008).

While clear connections have been demonstrated for motor-cognition, motor-language, cognition-social, and language-social relationships, the social and motor domains have been studied independently, without a strong focus on the potential inter-relatedness. It is possible that these two domains are related and acting upon each other. If this is the case, then it is plausible that improvements in one domain could result in improvements in the other. If these two domains are inter-related, then early intervention effectiveness could be improved by including motor skill specific components to existing programs.

Purpose Statement

The purpose of this study was to examine the relationship of social and motor skills in young children with autism. The central hypothesis is that children with better motor skills will have better social communicative skills.

Specific aim 1: To determine the relationship of standardized motor skills and social communicative skills in children with ASD. Working hypothesis: Children with better motor skills would have better social communicative skills.

Specific aim 2: To compare the social communicative and motor skill relationship of children with autism to peers without autism. Working hypothesis: The known motor deficits in children with ASD would negatively impact their social development. Therefore, it was expected that the social communicative skills of children with ASD would be related to their motor skill performance.

Assumptions:

A core assumption of this study is that it is important for children to possess strong motor and social skills. Another assumption is that the measurement tools used in this study correctly assess the constructs for which they are designed to measure (instrumental assumption). The Peabody Developmental Motor Scales 2nd edition (PDMS-2) is only standardized for use in children up to 5 years of age, yet this study includes children up to 7 yrs of age. The PDMS-2 has been used in prior investigations of motor skills in children with ASD who are expected to have lower performance. Its use to measure motor scores children without ASD over the age of 5yrs may not represent a true reflection of these children's motor ability, yet this study assumes that it will still adequately capture motor differences between groups. The methodological assumptions are that the study design is appropriate for the two questions being asked and that the data collected for this study is suitable for answering the questions being examined.

Delimitations:

Results of this study are delimited to children between the ages of 2 – 7 years from eastern Oregon whose family chose volunteered to participate in this investigation.

Limitations:

As with all studies, this project is not without limitations. One such limitation relates to group assignment, which is determined by parental report of the participant's diagnosis of ASD. Therefore, it is possible that a child who is on the autism spectrum but does not have a clinical diagnosis could be included in the non-ASD group. Also, due to the association of this study with a motor intervention, some participants may have been motivated to participate due to parental perception of a need to improve the child's motor performance. Lastly, this study had a small sample size (n = 17).

Definitions:

Motor skills: Motor skills are voluntary, goal-oriented movements related to (a) stationary, (b) locomotion, (c) object manipulation, (d) grasping, and (e) visual-motor integration tasks.

Fundamental motor skills (FMS): consist of locomotor and manipulative coordination patterns (e.g. running, galloping, skipping, catching, throwing, striking, and kicking) that form the foundation for activity and culturally specific motor skills that emerge during the context-specific motor skills period (Clark, 1995, 2005).

Motor abilities: motor abilities are the underlying processes that influence the performance of movement examples include general ability to maintain balance or the eye-foot coordination needed to run toward a moving ball, and make the contacted required for completing a successful pass during a soccer game.

Literature Review

In the US, 1 in 88 children are diagnosed with ASD (CDC, 2012). Though a recently released study suggests that in school-aged children prevalence of ASD may actually be as high as 1 in 50 (Blumber et al., 2013). To date, research findings suggest ASDs have genetic and neurobiological origin (Just, Keller, Malave, Kana & Varma, 2011; Takarae, Minshew, Luna, & Sweeney, 2007), yet the exact etiology remains unknown (Willemsen-Swinkels & Buitelaar, 2002; Volkmar, Lord, Bailey, Schultz, & Klin, 2004). ASD is a pervasive developmental disorder characterized by social communicative deficits and restricted interests and behaviors (APA, 2000). These characteristics lead to daily difficulties for individuals with ASD including expressing one's thoughts and feelings, correctly interpreting body language or facial expression of others, and appropriately engaging socially with others (McConnel, 2002).

Impairment in the social communicative domain is first noticeable in infancy and is often indicated through some of the following social communicative behaviors: the child's failure to respond to their name, poor use of eye contact, and decreased interest in others (Osterling, Dawson, & Munson, 2002). Individuals with ASD often use poor or unusual eye contact and limited facial expressions toward others (McConnel, 2002; Osterling, Dawson, & Munson, 2002), and some children may show little or no pleasure in interacting with others. Other social impairments include decreased quality of social overtures (e.g. failing to make eye contact with a person while trying to gain his attention or attempts to initiate social interaction with others may being restricted to personal interests or demands of the child), decreases in the quality of social response (e.g. inappropriate, inconsistent, or socially awkward response to a social situation), and overall rapport (Lord, 2000). Communication impairments first present through delayed babbling and speech development (Filipek et al., 1999). Compared to typically developed peers, children with ASD often display reduced frequency of vocalizations directed toward others and a decreased amount of spoken language. For those who never develop spoken language, communication may be conducted through sign language and use of pictorial or computerized speech generating devices, however this type of communication often takes time to develop and requires individualized and adapted instruction (Myers & Johnson, 2007). In addition to quantitative impairments, individuals with ASD also exhibit qualitative impairment in communication. Such impairments include idiosyncratic use of words and phrases, echolalia, and difficulty initiating and sustaining conversation (Lord, 2000). Non-verbal communication may also be affected; this may include difficulty with facial expressions, use of gestures, pointing, and showing (Williams & Minshew, 2004). Sometimes individuals with ASD also engage in repetitive and stereotypic behaviors such as hand flapping, finger flicking, rocking, spinning, running, spontaneous vocalizations, clucking and screaming (APA, 2000). Other behaviors such as biting, hitting, kicking, and head banging may be present as stereotypic behaviors and in some cases self-injurious behavior.

Motor Skill Deficits in ASD

Although the criterion impairments in ASD focus the social and communicative domains, children with ASD also display deficits in motor skill performance (Miyahara et al., 1997; Provost et al., 2007; Bhat et al., 2011). Motor skill deficits in individuals with ASD have been recognized for as long as the disorder has been identified. In the original descriptions of the disorder, both Kanner (1943) and Asperger (translated in Firth) (1991) noted the clumsiness of patients.

Although the discussion on motor behavior in children with ASD typically resides around stereotypic behaviors, numerous studies present evidence of motor skill impairments in individuals with autism (Green et al., 2009; Ozonoff et al., 2008; Staples & Reid, 2010; Tettelbaum et al., 1998). Teitelbaum and colleagues (1998) gathered information about early movement in children with and without autism. They found that the children with autism were delayed in milestones such as rolling over, sitting, crawling, standing, and walking. Miyahara et al. (1997) conducted an investigation of motor skill performance in children between 6-15 years of age with learning disabilities (LD) and Asperger's syndrome (AS) using the Movement Assessment Battery for Children (Movement ABC) (Henderson & Sugden, 1992) and found motor skill delays in total test scores for both groups. Of the three subsets of the Movement ABC (manual dexterity, ball skills, and balance), a statistical difference between the children with AS and those with LD was found only in manual dexterity ($p < 0.05$). However, the difference on the ball skill subscore ($p = 0.09$) was approaching significant level. Provost et al. (2007) compared the motor skills of young children (21-41 months of age) with ASD, children with other developmental delays (DD), and children with DD but no motor delays (NMD) using both the Bayley Scales of Infant Development-2nd Edition (BSID II:Bayley, 1993) and the Peabody Developmental Motor Scales-2nd Edition (PDMS-2:Folio & Fewell, 2000). Results indicated that children with ASD had motor skill delays similar to the children with DD. Furthermore according to the outcomes of the BSID II, 63% of the children with ASD showed motor delays greater than 25% based on age, thus qualifying them for early intervention services due to motor skill delays alone. The PDMS-2 outcomes revealed that most of the children with ASD scored in the below average or lower classification levels of this assessments. Using the age-equivalent score, 68% of the children with ASD had motor delays of at least 25% and would have qualified for early intervention services. An additional study in children between the ages of 12-36 months with ASD provides evidence that the difference between chronological age and motor age equivalence increases with age in both gross and fine motor performance (Lloyd, MacDonald, & Lord, 2011). In other words, the motor deficits in young children with autism widen as they age. Another important result of the study was the discovery that between ages 1-3 years fine and gross motor skill deficits escalates (Lloyd et al., 2011). Staples and Reid (2010) compared fundamental motor skills of children (9 – 12 years of age) with ASD compared to children matched on (a) chronological age, (b) development, and (c) mental age. An interesting finding of this study was that children with ASD performed motor skills at a level of children who were half their chronological age. This study established that individuals with ASD experience motor skill deficits not just delays, meaning that individuals with ASD never reach the same level of motor skill performance as peers without ASD. In their motor skill-based investigations Lloyd et al. (2011), Staples and Reid (2010), and Green (2009) controlled for cognitive function; results from these studies disprove the common misconception that the motor skill impairments in individuals with ASD are solely a result of low cognitive function.

Research examining stability and balance in individuals with ASD suggests underdevelopment in motor control systems such as vestibular input and processing possibly due to structural differences and dysfunction of the cerebellum and basal ganglia (Fournier et al., 2010; Molloy, Dietrich, & Bhattacharya, 2003). When testing the afferent systems involved in balance, Molloy et al. (2003) created four conditions to test effects of visual and somatosensory modification. Vision was adjusted by having the children stand with eyes either open or closed and somatosensory input was varied by having them stand on solid surface or a piece of foam. They found that children with ASD rely more on visual cues compared to typically developed children. These results also showed that the most difficult condition for children with ASD was created by the removal of visual input and modification of somatosensory input. Results of another study examining postural sway in individuals with ASD support the afferent condition findings of Molloy and her colleagues (Minshew, Sung, Jones, & Furman, 2004). The results from this study showed that reduced stability was observed in individuals with ASD and that this instability was specific to autism and not a result of any impairment in cognitive function. There was also a significant effect of age on postural stability, found in this study. In the typically developing control subjects, continuous improvement in postural stability occurred from age 5 years until 15-20 years, at which time stability reached what is considered adult levels. However, in individuals with ASD improvements do not begin until 12 years of age and never reach the level of adults without ASD (Minshew et al., 2004).

In addition to poor stability, individuals with ASD also experience difficulty with motor planning (Nazarali, Galzeborrk, & Elliott, 2009; Ozonoff et al., 2008) and motor imitation (McDuffie et al., 2006; Zachor, Ilanit, & Itzchak, 2010). These issues in stability, motor planning and motor initiation may impair the acquisition and execution of fundamental motor skills in children with ASD (Fournier et al., 2010). As discussed in the following section, the development of these skills is important for participation in many games and other play-based activities.

Typical Motor Development

Development of motor skills during the first few years of life are the most easily detected signs of growth for parents (Thelen, 2000). Movement is usually first detected during the third month of gestation and continues to develop throughout the individual's lifespan (Clark, 2007). Development in the motor domain is a dynamic process involving interaction of the individual and the environment (Thelen, 1995; Ulrich, 2010). Changes and growth occur through states of stability and instability, where periods of stability represent stages of development and periods of instability represent exploration, learning, and mastering of skills (Thelen, 1995). The six stages of motor development as defined by Clark (1994) include: (a) reflexive, (b) preadapted, (c) fundamental patterns, (d) context-specific, (e) skillful, and (f) compensation. Clark and Metcalfe (2002) use the imagery of climbing "the mountain of motor development" to describe progression through these developmental stages. As in mountaineering, all climbers must begin at the base of a mountain (the reflexive stage) and progress up the mountain (preadapted, fundamental patterns, context-specific stages) to reach the pinnacle (skillful stage). The climber's level of training and experience or in this case development, determines how far the person gets up the mountain.

The reflexive stage begins when movement is first detected in the womb and lasts until about the second week following birth. Primitive reflexes, such as grasping and rooting, occur in response to specific stimuli and are the hallmark movements during this time (Clark, 1994; 2007). As primitive reflexes diminish and are replaced by more self-directed movements infants enter the preadapted stage. During this stage children learn motor skills common to the human species yet not automatically programmed such as rolling over, sitting, standing, and walking (Clark, 2005). Independent walking and feeding, which are usually achieved by the first birthday, mark the end of the preadapted stage and the beginning of the fundamental patterns period (Clark, 1994, 2007). Children experience the fundamental patterns period from ages 1-7 years (Clark, 1994). During this time, children learn fundamental motor skills (FMS). FMS consist of locomotor and manipulative coordination patterns (e.g. running, galloping, skipping, catching, throwing, striking, and kicking) that form the foundation for activity and culturally specific motor skills that emerge during the context-specific motor skills period (Clark, 1995, 2005; Ulrich, 2000). In the context-specific motor skills phase, basic FMS patterns are modified to fit the explicit needs of activity in a particular sport, game, or dance (i.e. running is modified for hurdles or a gymnastics vault approach, throwing patterns are modified for softball or basketball, and jumping is modified for leaps and tour jetés). The pinnacle of the mountain represents the skillfulness period, were skills acquired during the context-specific period are further refined and lead to differences in level of performance such as novice, skilled, high school athlete, colligate athlete, and elite athlete. While development occurs in a forward progression most of the time, injury and aging can create changes in performance of acquired skills. With such changes comes a period of adjustment in motor performance to adapt to these changes. This is known as the compensation period (Clark 1994, 2005, 2007). While the compensation period is more commonly associated with changes in performance due to aging or injury, one can also view it from a disabilities perspective. For individuals with disabilities, motor development or performance may sometimes differ from that of individuals without disabilities. Therefore, although an individual with a disability may be climbing the mountain of development in the same direction of progression as an individual without a disability, but the level of skillfulness or what “achievement” of specific skills looks like may vary. For instance, a child with a mobility disability who uses a wheelchair “walking” equates to being able to propel and navigate the chair from one point to another. Also, this individual may learn skills such as throwing, but the desired technique of the skill may change due to physical limitations. In the typical population throwing technique normally emphasizes stepping forward with opposite foot related to the hand holding the ball and having truck rotation. For an individual who uses a wheelchair, the step component of throwing would certainly be eliminated and the trunk rotation might be eliminated as well.

According to Seefeldt (1980), early development that occurs during the preadapted and fundamental movement patterns periods has the greatest impact on later skill acquisition. Development of motor skills is dependent upon the individual’s motor abilities. Motor skills are voluntary, goal-oriented movements and motor abilities are the underlying processes that influence the performance of movement (Magill, 1998; Staples & Reid, 2010). In other words, motor abilities refer to the process and motor skills refer to the product.

One such process children develop during these periods is postural control. Although postural control is most associated with balance, it also involves manipulating your body to achieve a desired position and maintaining that position (Clark, 2007). Postural control is obtained through a complex process involving integration of information from the vestibular, somatosensory, and visual systems (Clark, 2007; Molloy, 2003). These systems work together to provide the central nervous system (CNS) with information regarding head orientation, body positioning in respect to support surfaces, and objects in one's environment. Achievement of balance requires that they body's center of gravity (COG) be within the body's base of support (BOS) (Nashner, 1989). Conditions of postural control can be either static or dynamic depending on the body's movement (Fournier, Hass, Naik, Lodha, & Cauraugh, 2010). Static postural conditions are present during sitting and standing tasks where there is no intentional movement. In static conditions, the center of mass COM and center of pressure (COP) remain close together. In dynamic conditions, such as those experienced during locomotor and object manipulation tasks, the COM moves away from the BOS. The ability to tolerate the separation of the COP and COM during transitions between static and dynamic states is known as dynamic postural control. During this process the (CNS) must use information its receiving from these systems to coordinate anticipatory movements (Fournier et al., 2010). Whether conditions are static or dynamic, it is the role of the central nervous system (CNS) to maintain equilibrium or balance so that the person does not fall. Complex motor skills like kicking and throwing while running, build on the foundation of postural control combining principles of static and dynamic conditions for balance along with coordinating movements of multiple body segments. Therefore, possessing this ability is important for participating in may play activities.

Play

The role of play as a context in which children learn and practice developmental skills has been well acknowledged in child development literature (Denham et al., 2001; Liberman & Yoder, 2012). Pellegrini and Smith (2007) theorize that play is a vehicle through which children can learn and practice behaviors to adapt to their respective environment. Although various definitions of play exist, common characteristics of play behavior include: spontaneity, self-generation, and intrinsic motivation; involves active engagement by participants; is flexible, meaning that the behavior is variable between individuals as well as environments; play brings about pretending and imagination; and is enjoyable to participants (Rubin, Fein, & Vandenberg, 1983). Using cognitive and social perspectives researchers have identified categories of play. Social categories include: (a) solitary play; (b) parallel play; (c) associative play; and (d) cooperative or peer play (Mastrangelo, 2009). Cognitive play includes: (a) objective play, (b) functional play, (c) symbolic or pretend play, and (d) games with rules (Mastrangelo, 2009). Behaviors during objective play focus on exploration and object manipulations. Take an infant playing with building block: the child's play may include fingering, gumming, or turning the block. The objectives of the child's actions are not to do anything with the block, but to learn about the block (e.g. shape, size, texture, taste, etc). During functional play, objects involved with an activity are used only in a manner associated with their appropriate use (i.e. a block is nothing more than a block is used for construction, a hair brush is used to brush a doll's hair, etc.) Children engaging in symbolic play start to involve pretense and fantasy in their activities. In such play, a block can represent a person or vehicle and a hairbrush may be used as a microphone. The children engaging in pretend play may also take on symbolic roles as they pretend to be grown-ups and act out behaviors and tasks the person being emulated might perform. In the next category of play, games with rules, children subscribe to pre-determined sets of rules and roles for a given activity. In a simple example using a game of tag, all participants understand that one person is "it" and has the responsibility to catch and "tag" another player. At this point the person who was "tagged" becomes "it" and now must catch and tag another player.

Motor and Social Communicative Skills in Play

Since many play activities for young children involve motor games (Provost et al., 2007), acquisition of motor skills is important for a successful play experience. Fine motor skills are needed to manipulate objects used in functional construction play and some symbolic play (i.e. building blocks and Legos®; using a stick as a wand or a cardboard tube as a sword). Also, many playground games and activities such as tag, hide-and-go-seek, jump rope games, and swinging involve locomotor skills. Additional gross motor skills are required for participation in several games with rules. For instances, kickball requires skills of running, kicking, aiming and foursquare requires catching, bouncing, and throwing skills. Successful engagement in these games and activities may not be possible for individuals with motor delays or deficits.

While many playground activities provide an opportunity to practice and further develop motor skills (Provost, et al., 2007) opportunities to develop and practice social skills also arise as children engage in peer play. For instance, as children engage in more abstract play with others, sufficient social communicative skills are required to include and inform other playmates (Liberman & Yoder, 2012). In particular, games with rules (e.g. Mother May I, Red Light, Green Light, kickball, etc) that involve tasks such as formation of teams, designation of leaders and officiators, enforcing and adjusting rules and require effective social communicative skills such as joint attention, self-expression, and conflict resolution. Other communicative abilities necessary for participating in such games include recognizing when someone is getting ready to pass a ball so that the intended receiver will successfully complete the pass. Equally important is recognizing when it is appropriate to pass the ball to another player, identifying to whom the ball should be passed, and ensuring that the intended person knows the ball will be coming to him and is ready to receive it. Some of the motor skills needed for such communication in games include pointing, gesturing, and showing, to name a few. Deficits of these motor skills may create barriers to successful social interactions in play due to inability to effectively communicate. Such circumstances then result in a missed opportunity to hone emerging social skills.

Early Intervention in Treatment of ASD

The most common treatment option for children with ASD that has had success is early intervention (Dawson et al., 2010; Kasari, 2005; Rogers & Vismara, 2008). In 2001, the National Research Council (NRC) identified 8 areas of focus that should be included in educational objectives for children with autism. These areas include: (a) social skills; (b) verbal and non-verbal communication skills; (c) a functional symbolic communication system; (d) increased engagement and flexibility of play; (e) fine and gross motor skills; (f) cognitive skills; (g) replacement of problem behaviors with more appropriate behaviors; (h) skills and behaviors that lend to academic success. Of the 8 areas, social and communicative domains have received the most attention (Dawson 2010; National Research Council, 2001). Indeed the emphasis or social skills in interventions for children with ASD is a predominate topic within treatment literature (Volkmar, Lord, Bailey, Schultz, & Klin, 2004). Matson and colleagues (2007) conducted a systematic review of 79 treatment studies, which focused on improving social skills in children with ASD. This review concentrated on methods of intervention, however specific skills of interest in many of the social skill interventions include joint attention, imitation, and play (Kasari, 2005, 2010;Williams, Reddy & Costall, 2001). The most preferred treatment option for young children with ASD is Early Intensive Behavioral Intervention (EIBI), which incorporates the principles of applied behavior analysis (ABA) (Lovaas, 1987; Reichow, 2012; Vismara & Rogers, 2010). ABA uses rewards and reinforcement principles of learning and step-by-step teaching to shape behavior (Eapen, Črnčec, & Walter, 2013). Overall intervention goals of ABA include (a) decreasing or eliminating undesired maladaptive behaviors, (b) reducing circumstances in which maladaptive behaviors occur, and (c) increasing or maintaining desirabe adaptive behaviors (Francis, 2005; Myers & Johnson, 2007).

One available early intervention program is the Early Start Denver Model (ESDM) (Rogers & Dawson, 2009), which is based on the Denver Model. ESDM is a play-based intervention that integrates ABA with developmental and relationship-focused methods (Rogers & Dawson, 2009). The ESDM is designed for children 12 months – preschool age and thus far is the only empirically evaluated EIBI program for children under 30 months old (Dawson et al., 2010). The overall goals of ESDM are to improve communication and social attention, this program has a specific focus on joint attention, imitation, affect, sharing, visual reception, and both receptive and expressive communication (Rogers & Dawson, 2009). As with many other early intervention strategies, the play-based context allows for an opportunity to practice motor skills. In fact, in their ESDM study Eapen and colleagues (2013) found improvements in the Motor Skills domain and Gross-motor sub domain scores of the Vineland Adaptive Behaviour Scales – 2nd edition (VABS-II: Sparrow, Cicchetti, & Balla, 2005). However, a specific content focus on improving motor skills is missing in this early intervention strategy even though this area as been recognized as a core focus by the National Research Council.

Researchers have noted this lack of adherence to the National Research Council's recommendations. In her advocacy for more stringent early intervention practices, Ulrich (2010) brings attention to the importance of ensuring that young children with motor disabilities have the same opportunity to experience active exploration and practice moving and controlling their bodies, as children without disabilities. Without such opportunities the author suggests potential devastating consequences, including missed opportunities to discover ways to functionally resolve challenges presented by both individual and task constraints. Furthermore, inattention towards correcting motor impairments permits development of secondary and tertiary physiological and functional conditions.

Another support for targeting motor performance in early intervention programs is that social and physiological domains are closely related (MacDonald, Jaszewski, Esposito, & Ulrich, 2011) and several early interventions use play as the medium to present, teach, and practice appropriate and desirable social communicative skills. Therefore, it would be logical to presume that improving motor skills could potentially influence successful outcome of the social communicative goals of intervention strategies (Liberman & Yoder, 2012). If such were the case, intervention designs that include both motor and social communicative objectives could potentially produce an additive effect on overall improvement and function in young children with ASD. However, it must first be determined to what extent the social and motor domains are related. Therefore, the purpose of this study is to examine the relationship of social and motor skills in young children with and without autism.

Methods

Participants

Children with ASD and children without ASD between the ages of 2-7 years were recruited to participate in this study via distribution of flyers throughout the community and organizations with specific interests related to this study. The specified age range was selected to align with the typical age range to qualify for early intervention services (ages 2-5 years) and early school years (ages 5- 7 years). Thirty-four participants responded to recruitment flyers. Of those 34 participants, 17 participants withdrew prior to assessments for the following reasons: no response to scheduling efforts (n=8); distance from home to study site (n=5); not show to appointment (n=1); other (n=3). Of the remaining 17 participants, 8 had a diagnosis of ASD and 9 did not (see figure 1).

Participant Compensation

Caregivers were provided with performance summary reports from all assessments. These reports included percentile ranking and age equivalence scores of the child's performance and developmental assessments (motor skills and cognitive assessments). There was no monetary compensation for participants.

Procedures

Prior to recruitment, IRB approval from Oregon State University was obtained for all aspects of this study (see appendix A). The participants were recruited from local childcare centers, schools, clinics, and parent support groups through distribution of flyers and word of mouth. A verbal and written explanation of the study was presented to the caregivers of the recruited children. Informed consent was obtained from all caregivers for participation in this study. This included the participation of the caregiver and their child's participation in this study. All child participants assented to participation in the study. The child was asked, "Do you want to play?" The children's engagement with the materials (investigator(s), parent(s) or objects/ activities) was considered positive assent.

A battery of assessments was administered to assess the developmental level, motor skills, and social communicative skills. Administration of these assessments usually occurred over 2 sessions. The first session was approximately 2.5 hours and the second about 1.5 hours. Activities of the first session included obtaining informed consent and assent, demographic information, administration of the Mullen^{TM} and the Autism Diagnosis Observation Schedule (ADOS). The Peabody Development Motor Scales 2nd Ed (PDMS-2) was administered the second session. Some flexibility in assessment order and time frame was allowed to accommodate behavior and scheduling needs of the participants. For instance, accommodations were made as necessary in instances where the child required more time to complete the assessments or when the caregiver requested that all assessments take place over one day. When all assessments were given the same day, the child was allowed ample opportunity for breaks to prevent burnout or allow for snacks/lunch. Scoring or computing the results for all assessments occurred immediately following completion of the day's session after the participant was dismissed. Then, caregivers were provided with a summary of the assessment results.

Assessments

Supplemental information (See Appendix B). Caregiver(s) completed a questionnaire to provide additional demographic information about participants.

Diagnostic assessment. Each child completed the Autism Diagnostic Observation Schedule (ADOS) (Lord, 2000) to confirm or exclude ASD diagnosis. The ADOS is a standardized diagnostic tool commonly used in practice and research of individuals with or suspected of having autism (Gotham et al., 2007, 2009; Lord, 2000; Matson & Sipes, 2010). It contains four modules, which measure communication, social interaction, and play in individuals with or suspected of having ASD. Each module is specific to the language development of the participant: module 1 (preverbal/single words), module 2 (phrase speech), module 3 (fluent speech), and module 4 (fluent speech- adolescent/adult). Modules 1, 2, and 3 were used for this study in accordance with the participant's level of language as determined during the developmental assessment and/or through conversations with the caregiver. The ADOS typically requires 45-60 minutes for administration.

Developmental assessment. The Mullen™ Scales of Early Learning (MSEL) was our primary tool for this assessment. The MSEL is a standardized tool commonly employed for this use in clinical settings (Mullen, 1995). It consists of 5 subscales: (a) gross motor, (b) fine motor, (c) visual reception (non-verbal problem solving), (d) receptive language, and (e) expressive language. Using the fine motor, visual reception, receptive language, and expressive languages scales, a standard early learning composite score can be obtained. This composite score is considered comparable to "IQ" scores obtained from more traditional assessments. For the purposes of this study, the visual reception (nonverbal problem solving) scale was used for analysis- this scale is a better representation of IQ for children with autism, based on its "non-verbal problem solving qualities". Typical time for administration is 30-45 minutes.

M**otor skill assessment.** The Peabody Developmental Motor Scales 2nd Ed is a standardized assessment of gross and fine motor skills in children age birth – 5 years. It consists of 6 subscales: (a) reflexes, (b) stationary, (c) locomotion, (d) object manipulation, (e) grasping, and (f) visual-motor integration. The reflexes subscale contains 8 items and is only administered to children 11 months and younger since these reflexes should be integrated by the first year of life. The stationary subscale contains 30 items to test the child's ability to control stability. The locomotion subscale contains 89 items to assess ability to move from one place to another. Object manipulation, or a child's ability to manipulate balls (i.e. throwing, catching, kicking) is measured in this 24-item subscale. This subscale is only administered to children 1 year and older since these skills are not present until after the reflexes have integrated. The grasping subscales measures how well one can use his/her hands through 26 items. The visual-motor integration subscales consists of 72 items to measure use of perceptual skill to perform eye-hand coordination tasks. All items are scored 0, 1, or 2, with 2 indicating mastery of skill, with 1 indicating partial ability, and 0 indicating failure to perform or attempt the task. Raw scores from the subtest can be converted to age equivalent, percentile, and standard scores using appendices provided in the test manual. Standard scores from the reflexes, stationary, locomotion, and object manipulation can be combined to provide a gross motor quotient (GMQ). Standard scores from the grasping and visual-motor integration subscales provide a fine motor quotient (FMQ). Summation of the GMQ score and the FMQ score results in the total motor quotient (TMQ) score. The TMQ is an indication of overall motor ability. Total administration time for the PDMS-2 is 20-45 minutes. Because participants of this study exceed the normalized age range for the PDMS-2, only raw scores were used in analysis of motor performance.

Social communicative skills. Evaluation of social skills was assessed using Autism Diagnostic Observation Schedule- calibrated severity scores (CSS) (Gotham et al., 2007; Gotham et al., 2009). The CSS scores are calculated based upon performance of the social communicative skills included in specific presses of the ADOS. These scores measure the severity of ASD symptoms on the ADOS not functional impairment to allow comparison of ADOS scores across time due to changes in age and language development (Gotham, Pickles, & Lord, 2012).

Data analysis

Descriptive analysis were obtained for all participants, and separated by group (ASD, nASD). ANCOVA was used to compare motor skills and social skills between groups holding constant nonverbal problem solving (MSEL visual reception organization subscale) and age. These comparisons were conducted to confirm differences of motor and social performance between groups. A Pearson correlation analysis tested the studies first specific aim regarding the relationship of motor skills and social for all participants as well as those within each group (children with ASD, children without ASD). Data analysis was conducted using IBM®SPSS v. 20.

Results

A total of 17 participants were recruited for this study (ASD n = 8, nASD n = 9). Descriptive information (mean, standard deviation, frequencies) for participant age, gender, and diagnosis can be found in Table 1. The average age for all participants combined was 55.7 months; the average age for participants with ASD was 59.5 months, for participants without ASD (nASD) was 52.3 months. While the group with out ASD was about 7 months younger than the group with ASD, this difference was not statistically significant. Only two females participated in the study; both were in the group without ASD. Descriptive demographic information of participants can be found in Table 2.

Descriptive information about the assessments for cognition, social, and motor skills is presented in Table 3. Cognitive assessment of participants using the MSEL was reported as non-verbal problem solving. The means and standard deviations for participants with ASD were 47.75 (SD = 16.15) and for those without ASD were 52.62 (SD = 10.99). Assessment of social skills (ADOS-CSS scores) resulted in 7.37 (SD = 1.5) for ASD and 1.28 (SD = 0.75) for nASD. Motor skills were reported as raw scores, age equivalence, and a difference between chronological age and age equivalence of performance (Chronological age – PDMS-2 age equivalence score). The age difference scores were used to better illustrate motor deficits of children with ASD. Such reporting has been used in previous studies (Lloyd et al., 2013) to better understand the depth of motor deficits in children with ASD. Both age equivalent scores and age differences, age is reported in months. The total possible points for each category of raw scores are as follows: stationary – 60, locomotion – 178, object manipulation – 48, grasping – 52, visual motor integration – 144, sum of gross motor – 286, sum of fine motor – 196, and sum of total – 482. In all motor skill scores, means from the ASD group are smaller than means of nASD group, however a significant difference was not seen in object manipulation and grasping (see Tables 3 & 5). Also, differences in chronological age and motor equivalent age were larger for the ASD group than for the nASD group. Results for group differences in social skills and non-verbal problem solving is reported in Table 4. A statistically significant difference existed for social skills ($p < 0.01$) but not for non-verbal problem solving ($p = 0.49$).

Results for non-verbal problem solving were missing for one participant in the nASD group. Since comparison of motor skills were determined using ANCOVA holding nonverbal problem solving (determined by age equivalence of MSEL visual reception subscale score) constant, motor scores of that participant were excluded from analysis. These results can be found in Table 5. Statistically significant differences were found between groups in the following motor skill categories and subscales: total motor ($p < 0.001$), gross motor ($p < 0.01$), stationary ($p < 0.01$), locomotion ($p < 0.01$), fine ($p < 0.01$), and visual motor integration ($p < 0.01$). Additionally, differences in the grasping subscale ($p = 0.07$) were approaching significance.

Although raw scores were used for motor comparisons between groups, age-equivalent scores were also determined (see Table 3). These scores were used to determine differences between a participant's chronological age and the age level of motor performance (chronological age - PDMS-2 age equivalent score; see Table 3). These age-performance differences between groups were compared using ANCOVA; children with ASD had significantly larger differences in stationary ($p < 0.05$), locomotion ($p < 0.05$), and grasping ($p < 0.01$) skills (see Table 6). Comparison between groups for birth weight, age of sitting, and age of walking were also conducted using ANOVA (see Table 7). There were no significant differences between group for birth weight ($p = 0.44$ and age of sitting ($p = 0.37$). However, there was a significant difference between groups for age of walking ($p < 0.05$).

Correlation between social and motor skills within groups were conducted using Pearson product-moment correlation coefficient for raw scores of each subscale of the PDMS-2, the sum of gross motor raw scores, the sum of fine motor raw scores, and the sum of total raw scores (see Table 8). Results differed from expectations in that no relationship was observed in most categories. However, a moderate negative relationship was observed for grasping scores ($r = - 0.50$). Due to this lack of strong relationship of motor and social skills within groups, continuation of correlation analysis between groups was discontinued.

Figure 1. Participants

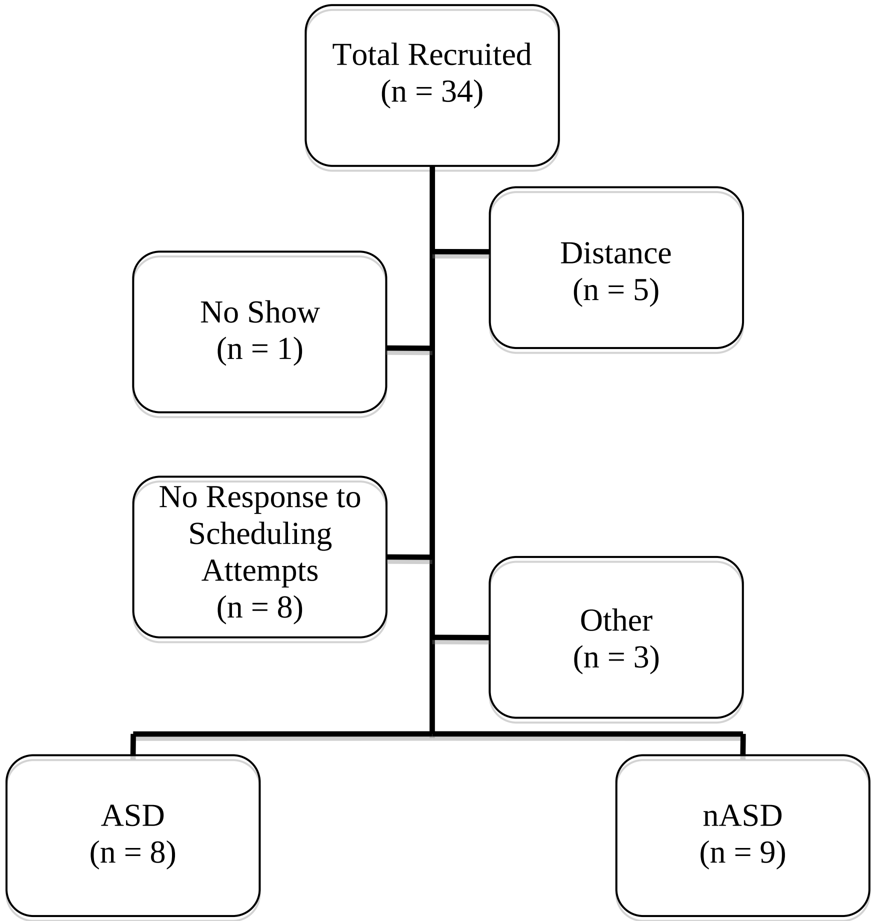

Table 1. Participant Gender and Motor Milestone Descriptives.

	ASD		nASD		Total	
Diagnosis	47.0%	(8)	52.9%	(9)	100.0%	(17)
Gender						
Male	100.0%	(8)	77.8%	(7)	88.2%	(15)
Female	0.0%	(0)	22.2%	(2)	11.8%	(2)
	M	SD	M	SD	M	SD
Age (in months)	59.50	13.00	52.30	17.78	55.70	16.26
Birth Weight	3.30	0.65	3.57	0.68	3.43	0.65
Age Sitting	5.43	1.65	6.08	0.49	5.71	1.30
Age Walking	13.75	2.96	10.75	1.69	12.25	2.80

Table 2. Participant demographics.

Ethnicity			
Mixed	25.00%	0.00%	12.50%
Caucasian	62.50%	75.00%	68.80%
Other	12.50%	25.00%	18.80%
Mother's highest level of education			
High School	0.00%	0.00%	0.00%
GED	12.50%	0.00%	5.90%
Associate's or 2-yr degree	12.50%	0.00%	5.90%
BA, BS, or 4-yr degree	50.00%	22.20%	35.30%
MA, MS, MBA	0.00%	33.30%	17.60%
PhD, MD, or other medical degree	0.00%	22.20%	11.80%
Some College	25.00%	11.10%	5.90%
No Degree		11.10%	17.60%
Father's highest level of education			
High School	12.50%	12.50%	12.50%
GED	0.00%	0.00%	0.00%
Associate's or 2-yr degree	0.00%	0.00%	0.00%
BA, BS, or 4-yr degree	50.00%	0.00%	25.00%
MA, MS, MBA	25.00%	25.00%	25.00%
PhD, MD, or other medical degree	0.00%	62.50%	31.30%
Some College	12.50%	0.00%	6.30%
No Degree	0.00%	0.00%	0.00%
Income			
Under 20K	14.30%	0.00%	6.70%
20-40K	28.60%	12.50%	20.00%
40-60K	28.60%	12.50%	20.00%
60-80K	28.60%	37.50%	33.30%
80-100K	0.00%	37.50%	20.00%
Over 100K	0.00%	0.00%	0.00%

Table 3. Performance of cognitive, social, and motor assessments.

	ASD			nASD		
	n	M	SD	n	M	SD
Non-verbal Problem Solving	8	47.75	16.15	8	52.62	10.99
Social Skills (ADOS-CCS scores)	8	7.37	1.50	9	1.28	0.75
PDMS- 2 Raw Scores						
Stationary	8	44.75	5.20	9	49.33	4.94
Locomotion	8	144.00	20.17	9	154.22	17.13
Object Manipulation	8	31.25	4.97	9	32.55	11.30
Grasping	8	43.00	6.50	9	47.88	4.01
Visual Motor Integration	8	122.37	16.72	9	128.55	11.56
Gross Motor Raw Scores Sum	8	220.00	28.74	9	236.11	30.92
Fine Motor Raw Scores Sum	8	165.37	19.65	9	176.44	14.82
Total Motor Raw Scores Sum	8	385.37	44.39	9	412.55	42.39
PDMS-2 Age Equivalent Scores (in months)						
Stationary	8	37.00	13.59	9	48.55	10.41
Locomotion	8	41.00	11.10	9	48.66	13.69
Object Manipulation	8	37.00	6.09	9	40.88	15.74
Grasping	8	30.62	16.88	9	51.44	18.76
Visual Motor Integration	8	46.50	16.36	9	50.55	16.07
Age differences (chronological age - PDMS-2 age equivalent score)						
Stationary	8	22.50	18.94	9	3.77	10.86
Locomotion	8	18.50	18.35	9	3.66	10.17
Object Manipulation	8	22.50	12.42	9	11.44	8.14
Grasping	8	28.87	23.49	9	0.88	14.32
Visual Motor Integration	8	13.00	21.56	9	1.77	12.40

Table 4. Comparison of non-verbal problem solving and social skills between groups.

	Sum of Squares	df	Mean Square	F	Sig.
Non-verbal Problem Solving					
Between Groups	95.063	1	95.063	0.498	0.492
Within Groups	2673.375	14	190.955		
Total	2768.438	15			
Social Skills (ADOS-CCS scores)					
Between Groups	112.452	1	112.452	28.382	0.000*
Within Groups	59.431	15	3.962		
Total	171.882	16			

*Indicates statistical difference.

Table 5. Comparison of performance between groups using PDMS-2 raw scores controlling for non-verbal problem solving.

	Type III Sum of Squares	df	Mean Square	F	Sig.
Stationary	239.679	2	119.84	25.935	0.000*
Locomotion	2779.621	2	1389.811	8.814	0.004*
Object Manipulation	162.227	2	81.113	1.375	0.287
Grasping	159.588	2	79.794	3.174	0.075
Visual Motor Integration	1711.85	2	855.925	9.934	0.002*
Gross Motor Sum	6381.952	2	3190.976	8.707	0.004*
Fine Motor Sum	2758.101	2	1379.051	11.409	0.001*
Sum of Total Motor	17503.077	2	8751.539	16.765	0.000*

*Indicates statistical difference.

Table 6. Comparison of difference in chronological age and motor age equivalent scores

	Type III Sum of Squares	df	Mean Square	F	Sig.
Stationary	2399.568	2	1199.784	6.375	0.012*
Locomotion	1800.248	2	900.124	5.366	0.020*
Object Manipulation	668.188	2	334.094	3.039	0.083
Grasping	5027.93	2	2513.965	8.814	0.004*
Visual Motor Integration	1530.015	2	765.007	3.057	0.082
Gross Motor Sum	1099.346	1	1099.346	1.227	0.285
Fine Motor Sum	518.962	1	518.962	1.745	0.206
Sum of Total Motor	3128.962	1	3128.962	1.666	0.216

*Indicates statistical difference.

Table 7. Comparison of difference in birth weight, age of sitting, and age of walking between groups.

	Sum of Squares	df	Mean Square	F	Sig.
Birthweight	0.271	1	0.271	0.611	0.448
Age Sitting	1.430	1	1.430	0.840	0.377
Age Walking	36.000	1	36.000	6.184	0.026*

*Indicates statistical difference.

Table 8. Correlations of PDMS-2 raw scores and social skills (ADOS-2 CSS).

Motor Skills (PDMS-2 Raw Scores)		Social Skills (ADOS-2 CSS) ASD	nASD	Total
Stationary	Pearson Correlation	-0.077	-0.170	-0.420
	Sig. (2-tailed)	0.855	0.663	0.093
	N	8	9	17
Locomotion	Pearson Correlation	-0.202	-0.252	-0.352
	Sig. (2-tailed)	0.631	0.514	0.166
	N	8	9	17
Object Manipulation	Pearson Correlation	0.291	0.104	0.019
	Sig. (2-tailed)	0.485	0.791	0.942
	N	8	9	17
Grasping	Pearson Correlation	-0.348	-0.277	-0.502
	Sig. (2-tailed)	0.399	0.470	0.040
	N	8	9	17
Visual Motor Integration	Pearson Correlation	-0.069	-0.098	-0.227
	Sig. (2-tailed)	0.871	0.802	0.381
	N	8	9	17
Gross Motor Sum	Pearson Correlation	-0.106	-0.129	-0.290
	Sig. (2-tailed)	0.803	0.742	0.259
	N	8	9	17
Fine Motor Sum	Pearson Correlation	-0.174	-0.151	-0.345
	Sig. (2-tailed)	0.680	0.697	0.175
	N	8	9	17
Total Motor Sum	Pearson Correlation	-0.146	-0.147	-0.335
	Sig. (2-tailed)	0.731	0.706	0.188
	N	8	9	17

Discussion

Overall, social and motor evaluations supported previous findings that children with ASD perform lower than their peers without ASD. Children with ASD were significantly lower in social skills than children without ASD, which was not surprising due to the core social features of the disorder. Also, social skill criterion was constrained to ASD symptomology, so it is logical that children without ASD would have better social performance than children with ASD. As supported in previous studies, social performance for this study was determined using the calibrated severity scores from the ADOS (MacDonald, Lord, & Ulrich, in press). These scores are calculated based upon social affect and restricted and repetitive behaviors observed during an ADOS assessment and are used to compare severity of ASD symptoms across different modules of the ADOS assessments and different ages (Gotham, 2009).

In agreement with prior research showing motor delays and deficits in children with ASD, this study found significant differences in gross motor, fine motor, and overall motor performance between children with and without ASD. When comparing performance of motor subscales, significant differences between groups were found in all categories except grasping ($p = 0.075$) and object manipulation ($p = 0.287$). However, the difference in grasping approached significance and several prior studies have found a difference in object manipulation skills, suggesting that these categories may also be important (Berkeley, Zittel, Pitney, & Nichols, 2001; Green et al., 2002; Provost, 2007). Small sample size and variance could have influenced the detection of significance in the current study. Studies have shown that differences in motor performance are sometimes due to differences in cognitive ability (Miyahara, 1997; Staples & Reid 2010). Further support of motor impairments in children with ASD emerged when comparing differences between the chronological age of the participants and their age-equivalence in motor skill performance. Significant differences were found for stationary, locomotion, and grasping skills. Yet interestingly, there was not a significant difference in the object manipulation category, in which some skills involve combinations of skills from these three areas. It would be logical for differences in stationary and locomotion areas to be related to observed differences in balance and postural control for individuals with ASD, and that impairments in grasping could be the result of issues with proximal- distal neural pathways. However, object manipulation skills require both balance skills and control in arms, hands, legs, and feet. If these skills are unaffected, then the discussed theories explaining observations for stationary, locomotion, and grasping skills may not be valid. While these results are interesting, a very small representative of both populations was used in this study and there was large variance in performance for both groups. Larger studies need to be conducted to confirm our observations of stationary, locomotion, grasping, and object manipulation skills for children with ASD.

Another interesting motor finding developed from the comparison between groups of birth weight, age of sitting, and age of walking. Raw data shows that children with ASD weighed less at birth and took longer to achieve the ability to sit than the children without ASD yet, though no statistical significance was found between groups. Interestingly though, there was a statistical difference in age at which participants were able to walk ($p = 0.03$). On average, children with ASD were not able to walk until about three months after children without ASD. This finding may reflect a point at which development changes for children with ASD and could help identify a critical point of motor intervention for this population. However, further investigation is needed.

The motor and social performances discussed thus far are not novel. The unique aspect of this study is its attempt to demonstrate a relationship between motor and social skills among young children. This effort focused not only on typically developing children, but also included children with autism spectrum disorders for whom social and motor differences are well established (Dawson et al., 2004; Lord et al., 2012; Provost et al., 2007; Staples & Reid, 2010). We did not detect a strong relationship between these two domains in this study. However, a number of factors may have influenced its detection, including small sample size (n = 17) and moderate variance in motor performances for each group. Furthermore, group participants were not matched in gender or age and current or prior reception of early intervention services was not taken into account while analyzing the data.

Currently there is no cure for autism, partly because its etiology is unknown. Until this changes, treatment will continue to focus on the implementation of behaviorally based interventions. Currently, the most recommended form of treatment is through early intervention strategies (Dawson et al., 2010; Rogers & Vismara, 2008). The National Research Council has recognized 8 developmental areas for early intervention objectives (National Research Council, 2001). While these objectives emanate from language, social, and motor domains, most early intervention programs focus on communicative and social behaviors (Kasari, 2005). Even a decade after these objectives were presented, diminutive attention and effort as been focused on the organizations recommendations for motor skills (Kasari, 2010). Many of these programs address their objectives through play-based activities, especially those targeting social behaviors (e.g. ABA, ESDM, and EIB). This is because it has been established that play activities provide a means for children to learn and hone developmental skills (Denham et al., 2001; Liberman & Yoder, 2012; Pellegrini & Smith, 2007). Since motor skills have an integral role in many play activities, it is valuable to examine how impairments in motor skills may affect participation in play. If motor impairments present barriers to play, do they also present barriers to social development?

A critical component to answering this question is characterizing the relationship between motor and social skills. While the results of this study were inconclusive, efforts should continue to address this knowledge gap. Future studies would benefit from larger sample sizes, matching participants on gender and age, and controlling for effects of early intervention treatment.

Conclusion

This study supports prior work demonstrating social and motor impairments in young children with autism spectrum disorders. While attempts to demonstrate a correlation of motor and social skills was unsuccessful, we acknowledge that this study was limited in sample size, lack of obtaining gender and age-matched participants, and a lack of controlling for children already receiving early intervention services. While the etiology of ASD remains uncertain, treatment of ASD symptomology remains a priority of autism research. From this perspective, further research examining the potential relationship between motor and social skills of children with ASD is needed.

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Appendices

Appendix A: IRB Protocol

RESEARCH PROTOCOL

06.10.2011

1. Protocol Title: A movement intervention for young children with autism spectrum disorder

PERSONNEL

2. Principal Investigator: Megan MacDonald
3. Student Researcher(s): Jacqueline Irwin (goes by "Megan")- graduate student ONID- irwinj, Jennifer Morgan- graduate student ONID- morgajen
4. Co-investigator(s): N/A
5. Study Staff: N/A
6. Investigator Qualifications: Megan MacDonald has a PhD in Kinesiology and extensive experience working with children with disabilities in educational settings and movement programs. She is also trained in all of the assessments that will be used for this study.
7. Student Training and Oversight: A project revision will be submitted to the IRB to add student researchers to this project as needed. Student investigators have completed CITI or NIH training. Any additional student researchers will also complete CITI or NIH training. Student researchers (not currently included in this study) will not have any interaction with the subjects nor will they have access to individually identifiable data until they are added to the study team via the IRB Project Revision process. Different levels of student involvement will be required for this project. Graduate students joining the project will be participating in all aspects of data collection including, participant recruitment, initial conversations with interested families, and participant screening (whether or not children fall within the age requirements/ basic eligibility requirements for this study, etc.). Graduate student's will be administering assessments and running the intervention. Initially all graduate students entering the project will receive training from the PI in terms of assessment administration and scoring as well as general training on autism spectrum disorder (behavior strategies for assessment and intervention administration, etc.). When appropriate, reliability checks will take place and graduate students will score assessments alongside the PI in order to ensure consensus. Similarly, intervention training will take place with practice involving facilitation of the movement intervention. Initially, the PI will be present and direct supervision will occur during the movement intervention. However, it is expected that graduate students will supervise and facilitate the intervention independent of the PI when the graduate students demonstrate a competent understanding of the intervention. Graduate students will also be administering other aspects of this project including data input and analyzing.

   It is not expected that the PI will have any extended absences during this project; however, the PI will work directly with the project team and ensure that there is a consistent agreement in project administration prior to any scheduled absences. In addition, the PI will schedule regular meetings with the research team to discuss issues that may arise.

Undergraduate students may also be participating in this project and will be listed as members of the study team. Their specific jobs could include: videotaping assessments and/or data input (& reliability checks with data input). In addition, undergraduate students may sometimes be asked to assist with childcare at the intervention site when families bring siblings in addition to the project participant. For example, in instances where the PI or graduate students need a moment to talk to the parents/ caregivers (consent, questions, etc), undergraduate students may be asked to play with or supervise the children while any formal/ informal meetings occur. Childcare will take place in the room immediately adjacent to the assessment room. Childcare will range from approximately 1 hour- 2.5 hours, depending on the length and duration of the participant assessment. Two study team members will be present when childcare is needed. Undergraduate students may also be asked to help set-up the assessment and intervention rooms with the necessary equipment. The PI will administer appropriate training or a graduate student assigned to the project for such instances. These are examples of aspects of the project that undergraduates may be a part of, however their specific involvement is not limited to the examples listed.

FUNDING

8. Sources of Support for this project (unfunded, pending, or awarded)

   This project will be funded through school funding assigned to the PI from the School of Biological and Population Health Sciences. These funds will be used to purchase standardized assessments and the necessary equipment needed to implement the movmeent intervention such as those indicated in the research protocol.

DESCRIPTION OF RESEARCH

9. Description of Research:
   Autism spectrum disorder (ASD or autism) is a pervasive developmental disorder characterized by deficits in social skills, communication and repetitive or restricted interests (APA, 1994). Research indicates that young children with autism experience delayed infant motor milestones resulting in deficits of fine and gross motor skills (Chawarska et al., 2007; Landa & Garrett-Mayer, 2006; Lloyd, MacDonald, & Lord, 2011; Teittelbaum, Teittelbaum, Nye, Fryman, & Maurer, 1998). Early intervention has been indicated as a priority in autism research- however the focus of early intervention typically falls within the social communicative domain (Dawson et al., 2010; Kasari et al., 2005). One aspect of early intervention that has been underexplored is the motor domain and movement-based interventions for young children with autism. The purpose of this study is to implement an early intervention for young children with autism using movement-based programming as the primary mode of intervention. Through a randomized control trial of a movement-based program it is hypothesized that children with autism will experience health- related benefits through improvements in motor skills,

social communicative skills and physical activity. Current research suggests that a relationship exists between the social communicative domain and the motor domain of young children with autism (MacDonald, 2011). However, a focused intervention targeted at improving motor skills and measuring health-related benefits in addition to social communicative benefits has not been studied. This study will be novel in addressing an area of content that has been underexplored in early intervention for young children with autism. Early intervention is at the forefront of autism research initiatives and this study aims to add to this researh priority.

The goal of this research is to publish through academic presentations at applicable conferences and through written publication in relevant peer-reviewed journals.

Specific aims:

a. Specific Aim 1: Do the motor skills of young children with autism improve through a movement intervention?
b. Specific Aim 2: Do the social communicative skills of young children with autism improve through movement intervention?
c. Specific Aim 3: Do movement interventions improve the physical activity patterns of young children with autism spectrum disorder?
d. Specific Aim 4: Is there a relationship between motor skills and social communicative skills in young children with autism?

Hypothesis:

a. Hypothesis Specific Aim 1: The motor skills of young children with autism will improve through a movement intervention.
b. Hypothesis Specific Aim 2: The social communicative skills of young children with autism will improve through a movement intervention.
c. Hypothesis Specific Aim 3: The physical activity patterns of young children with autism will improve through a movement intervention.
d. Hypothesis Specific Aim 4: There is a relationship between the motor skills and social communication skills of young children with autism and it is expected that the trajectory of this relationship will be positive with improvements in motor skills.

10. Background Justification:

Autism effects 1 in 110 individuals (CDC, 2011) and the rising prevalance has gained public attention. Improvements in standardized diagnostic tools have made earlier reliable diagnosis easier for young children with autism and diagnosis can occur as early as 12 months of age (previously diagnosis was not reliable until 3 years of age) (Luyster et al., 2009). Early diagnosis has led to children entering treatment earlier, which has a been deemed responsible for improved prognosis. Early intervention is the most widely cited and recommended mode of treatment for young children with autism (Dawson, et al., 2010; Kasari, et al., 2005; NRC, 2001). Evidence-based research shows that early intervention improves behavior in the social communicative domain such as IQ, language, adaptive behavior and autism diagnosis (ie. moving from autism to pervasive developmental disorder- not otherwise specified [PDD-NOS]- a diagnosis consistent with fewer symtoms) (Dawson, et al., 2010; Kasari, Gulsrud, Wong, Kwon, & Locke, 2010; Wong & Kwan, 2010). Although there is widespread agreement on the necessity of early intervention for young children with autism, there is less consistent agreement on the specific content of these programs (Dawson, et al., 2010; Kasari, et al., 2005; Lovaas, 1987; Rogers, Hall, Osaki, Reaven, & Herbison, 2000).

Motor skill deficits have been indicated in young children with autism including significant delays in fine and gross motor skills (Chawarska, et al., 2007; Landa & Garrett-Mayer, 2006; Lloyd, et al., 2011; Teittelbaum, et al., 1998). Children with autism have reached developmental motor milestones later than typically developed peers including but not limited to lying, righting, sitting, crawling and walking (Teittelbaum, et al., 1998). Unfortunately, these motor skill deficits widen as young children with autism age (Lloyd, et al., 2011). For example, a 12 month old child may experience a 3 month gross motor deficit (performing gross motor skills equivalent to a 9 month old), but an 18 month old child experiences a 6 month gross motor deficit (performing gross motor skills equivalent to a 12 month old). Therefore, as these young children age the motor skill gap widens compared to same-aged peers (Lloyd, et al., 2011). Other motor deficits in young children with autism include abnormal gait, weak postural control and poor motor planning (Fabbri-Destro, Cattaneo, Boria, & Rizzolatti, 2009).

Even though significant developmental delays in the motor domain are present in young children with autism, the primary focus of early intervention is on social communicative skills (Kasari, et al., 2005). This is not surprising giving that social communicative deficits are the hallmark characteristic of autism and early intervention has been successful at improving these skills. However, priorities in autism research are aimed towards discovering new and better content for early intervention (Kasari, et al., 2005; NRC, 2001). One area that has been underexplored is the motor domain.

For the most part, literature concerning the social communicative skills and motor skills of children with autism have been studied separately. However recent research, conducted by the primary investigator, suggests a relationship between these domains (MacDonald, 2011). In a young group of children with autism (ages 12- 48 months), fine and gross motor skills were directly related to the childrens social commuictive skills based on standardized tests (MacDonald, 2011). This relationship provides evidence that the motor skills of these young children appear to be influential in their social communicative skills. These results serve as the basis for this research study.

Based on the literature reviewed, young children with autism have deficits in social communication and motor skills. Early intervention for young children with autism has focused on social communicative skills through play-based activities. These interventions have been successful, yet there is continued support to build efficacious programs that better address and improve the growth and social communicative development for young children with autism. Proficient motor skills are useful in environments that foster play and improved motor skills could be advantageous for these young children to participate in developmentally appropriate activities that engage both the motor and social communicative domains. This study aims to understand how to improve motor skills in young children with autism as well as how improved motor skills impact health-related benefits and social communicative skills in young children with autism.

11. External Research or Recruitment Site(s)

Recruitment will occur through study fliers distributed to local childcare providers, healthcare providers, autism parent support groups and autism organizations (local chapters). Local programs providing services to young children with autism will also be contacted about posting or distributing a study flier (ie/ IMPACT at Oregon State University). Research for this study will take place at Oregon State University. The primary investigator is still building contacts in the Benton County/ Corvallis area. However based on past experience at another academic institution, this avenue of recruitment has been successful and supportive (organizations have been supportive towards informing their respective groups).

a) Name or description of each research site: Oregon State University

b) It is expected that the programs/ oranizations contacted will distribute information about this study through contacting their existing listservs. Study fliers will be distributed to interested organizations and participants.

c) A recruitment flier for this study is attached, a revision to this flyer includes children without autism.

12. Subject Population

Participants: Young children with and without autism between the ages of 2- 7 years 11 months will be recruited for this study. In addition, parent(s)/ caregiver(s) of the children will also be recruited to participate in this study.

Participant justification: Children with autism have been targeted due to specific needs to address deficits areas indicated in this disability, both social communicative and motor deficits. Children without autism have been targeted as a control group for specific aim 4: Is there a relationship between motor skills and social communicative skills in young children with autism?

. The age range of the child participants has been restricted to 2- 7 years 11 months in order to address the research question within an age range that typically qualifies for early intervention services and early special education services. Parent(s)/ caregiver(s) will also be participating in this study through questionnaires as well as active participants within the intervention (parents of children with autism only, working with their child).

Inclusion/ exclusion criteria: Inclusion criteria for participants with autism will require a diagnosis of autism, per parental report. All participants will also fall within the age range of 2- 7 years 11 months at entrance into the study. Participants will not be excluded based on ethnicity or gender. However, based on current autism statistics, we do expect to have a higher number of males enrolled in the study. Autism is 4 times more likely to occur in males (CDC, 2011).

Total enrollment number: The total enrollment number for this study is 50 young children with autism between the ages of 2- 7 years 11 months and their parent(s)/caregiver(s) and 20 young children without autism and their parents Therefore a total of 140 participants are being recruited for this study.

Chronological sequence of events (see attached basic study design):

13. Consent Process

    Consent/ Assent process: Consent for this study will be obtained from the parent/ caregiver of the child. Consent will be obtained prior to any study activities, following initial recruitment conversations; parents will be invited to come to the study site where informed consent will be obtained. At this time, parents/ caregivers will be invited to ask questions; they will also be clearly informed that their participation and their child's participation is voluntary and withdrawal from the study is possible at any time without negative consequence or penalty. Parents will be fully informed of the study through verbal explanations and through a detailed informed consent (please see the informed consent document for this study). Parents will consent for their child's participation as well as their own participation in this study (as previously described).

14. Assent Process

    It is important to keep in mind that some of the young children in this study have autism spectrum disorder. By nature of their disability many of the participants could be non-verbal and have difficulty interacting socially, especially with a new person (in this case the primary investigator or graduate students). There will be no written assent requested as age and developmental level make this too difficult. However, all children will be asked "do you want to play?". A positive assent will be indicated when the children engage with the materials in the room (investigator(s), parent(s) or objects/ activities).

    Therefore, the script for this assent is: "Do you want to play?"

15. Eligibility Screening:

    Eligibility criteria for this study includes the following:

    Child participants are between the ages of 2- 7 years 11 months (at study entrance). Children who are recruited with autism will have an autism diagnosis, indicated through parental report. The following eligibility criteria will be clearly explained during initial conversations as a part of recruitment. This information will be confirmed based on written confirmation through the demographic questionnaire (which will ask for the age of the child as well as whether or not the child has received a diagnosis of a disorder on the autism spectrum). Please note although eligibility criteria will be confirmed through the demographic questionnaire, data collection will not take place until parents have signed a consent form and have enrolled in the study.

This following script will be administered in initial conversations with interestd participants.

"This research study is for children between 2- 7 years 11 months with and without autism. Does your child meet the requirements of this study? Does your child have autism?"

Following the consent and assent process parents will be asked to fill out the supplemental questionnaire. This questionnaire asks a specific question related to eligibility, the child's age and if the parent/caregivers child has ever been diagnosed with autism (specific to families enrolling a child with autism). These are both important criteria to participate in this research study, the latter specific to participants with autism only. If these questions are omitted or answered outside of the age-range, the research team member will clarify these questions with the parent/ caregiver. If the children are outside of the age range or lacking an autism diagnosis (for participant with autism) the parents will be informed that they are not eligible to participate in the study.

Participants (child participants) who do not meet eligibility criteria will be informed immediately. Although autism diagnosis will be confirmed through the ADOS (Lord, 2000), eligibility criteria only requires diagnosis based on parental report for participants with autism. Children who do not fall within the age range of this study will be informed immediately (through the parents/ guardians) that they are not eligible for participation.

16. Methods and Procedures

<u>Methods</u>

Participants: Children between the ages of 2 and 7 years 11 months with and without autism spectrum disorder (ASD or autism) will be recruited for this study. The purpose of this study is to explore the health-related benefits of an 8-week movement intervention for young children with autism. Health-related variables will be measured before the intervention (baseline) for all participants, those with and without autism and at two time points following the intervention (immediately post-intervention and 2-months [approximately 8-weeks] post-intervention) for the participants with autism. The motor behaviors and social communicative behaviors of this young group of children with autism have been studied previously and significant deficits have been indicated in both areas (social communicative and motor) compared to their typically developed peers. Children without autism are being recruited to help answer specific aim 4: Is there a relationship between motor skills and social communicative skills in young children with autism? For the purpose of this question, young children without autism and their parent(s) will be recruited. However, these participants will only participation in the initial round of assessments (baseline).

Consent/ Assent process: Consent for this study will be obtained from the parent/ caregiver of the child who is recruited for participation in this study. Parents will be fully informed on the study through verbal and written explanation. The formal written explanation of the study will be detailed in an informed consent (please see the informed consent document for this study). Parents/ caregivers will consent for both their child's participation and their participation in this study (filling out demographics questionnaires and other related questionnaires about their child). An optional video and photography section appears on the consent. Parents have the option to choose if they agree to have themselves and their children photographed and video recorded for presentations at conferences and through other media publications. The young children in this study are between the ages of 2- 7 years and 11 months with and without autism. Assent will be verbally administered with the question "do you want to play?". A positive assent will be indicated through the children's engagement with the materials (investigator(s), parent(s) or objects/ activities).

Assessments

A number of assessments will take place throughout the study. A description of these assessments is listed below. With the exception of the demographic questionnaire all assessments will take place at 3 times points for children with autism- baseline (pre-intervention), immediately post-intervention and approximately 2 months post-intervention. The demographic questionnaire will only take place at the beginning of the study (baseline). Only baseline assessments will be administered to children without autism.

Diagnostic: All children will complete the Autism Diagnostic Observation Schedule (ADOS) (Lord, 2000). The ADOS is a semi-structured standardized assessment of communication, social interaction and play for individuals with autism or suspected of having autism. This diagnostic tool is commonly used in practice and research for individuals with autism and is considered the "gold standard" in terms of standardized autism diagnosis (Matson & Sipes, 2010). The ADOS consists of 4 modules, of which each is specific to the language development of the participants. It is expected that modules 1 & 2 will be used for this project (Module 1: preverbal/ single words & Module 2: Phrase Speech). In rare instances Module 3: Fluent Speech may be administered to participants who meet this language requirement. Language level is assessed during the free play activity (one of the schedules in the ADOS), through the Mullen™ or DAS-II- if administered first and in discussions with the parent/ caregiver. The administration time of this assessment is typically between 30- 45 minutes.

Developmental assessment: It is expected that most participants will be administered the Mullen™ Scales of Early Learning (Mullen ™), an individually administered comprehensive measure of cognitive functioning for children ages birth to 68 months (Mullen, 1995). The Mullen ™ consists of 5 scales: Gross Motor, Visual Reception Fine Motor, Receptive Language, and Expressive Language. The Mullen ™ has been used often with children with autism in both practice and research. The administration time of this assessment tool typically ranges between 45- 60 minutes.

If it is apparent that a child meets the ceiling levels of the Mullen™ the Differential Ability Scales-II (DAS-II) will be administered as an additional or alternative developmental assessment (in some instances the DAS-II may be needed at one time point or all time points depending on developmental level at entry) (Elliott, 2007). The DAS-II is a standardized comprehensive assessment of cognitive abilities for children ages 2- 17 years. The DAS-II consists of a variety of subtests including verbal and visual working memory, immediate and delayed recall, visual recognition and matching, process and naming speed, phonological processing and understanding of basic number concepts (Elliott, 2007). The administration time of this assessment tool typically ranges between 45- 60 minutes.

Motor assessment: The Peabody Developmental Motor Scales 2nd Ed (PDMS-2) is a standardized assessment of motor skills in young children age birth to 5 years (Murphey, Mackintosh, & McCoy-Roth, 2011). The subtests of the PDMS-2 include: reflexes (only administered to children birth to 11 months), stationary, locomotion, object manipulation, and grasping & visual-motor integration. The administration time of this assessment typically ranges between 20- 45 minutes.

Play-based video recording: a 10-minute video will be taken of the children and their parent (in the case where two parents enroll, one parent will be designated for video assessments). This video recording will take place with a standardized toy-set. A parent and the child will be asked to play as they typically would at home. Toys include, but are not limited to, blocks, dolls, constructions toys, dishes, kitchens toys, pop n pals, and other common games and toys used with toddlers. This play-based video sample is common for social communicative behavior coding in autism research.

Motor-based video recording: a 10-minute video will be taken of the children and their parent in the gym with a standard set of gymnasium equipment (i.e. mats, playground balls, soccer balls, bean bags, bowling pins, polly-spots, etc). The parent child dyad will be asked to play together using the space and equipment available.

Physical activity assessment: Physical activity will be measured using an accelerometer over a seven-day period. The participants will wear the monitor for all waking hours of the day on the waist using an elastic belt. The monitor will be worn for all activities except swimming, showering/bathing and sleeping. A social story (script) of the monitor will be read to each child (see attached social story).

Study design

i) Children between the ages of 2- 7 years 11 months with and without autism spectrum disorder will be recruited along with their parent(s)/ caregiver(s).

ii) Parent(s)/ caregiver(s) will complete an informed consent document for their child's participation and their participation in the study.

iii) An assent question will be administered to all children consisting of the question "do you want to play?". Confirmation of assent will be obtained through the child's engagement with the researcher(s), parent(s) or materials.

iv) Baseline assessments will take place for all participants with and without autism, these assessments include the following (for a more detailed information please see the descriptions above):

- ADOS (Lord et al., 2000)
- Mullen™ (Mullen, 1995)
  - If children meet the ceiling level on the Mullen™ the DAS-II will be administered (Elliott, 2007).
- PDMS-2 (Folio & Fewell, 2000)
- Video assessment 1- play-based video (parent-child dyad)
- Video assessment 2- movement-based video (parent-child dyad).
- Physical activity assessment using an accelerometer.

- It is expected that these assessments will take place over two days. Two hours will be scheduled on each day for the assessments. The researcher expects that the ADOS & Mullen™ will be assessed on day 1. The PDMS-2, Video 1 and Video 2 assessments will most likely take place on day two. A physical activity monitor will be sent home with the participant to wear for one-week following one of the assessment days.
- In some cases parents may choose to complete the assessments over one day- this will be accommodated if necessary. In other cases children need more time than allotted to complete the assessments- this will also be accommodated as necessary.

v) After the completion of all baseline assessments, children with autism will be randomized into one of two groups- either experimental or control.
Experimental/ intervention group:
Duration: 45 minutes per session, two sessions per week, 8 weeks
Location: Gymnasium (Women's building Oregon State University)
Children and their parent/caregiver will take part in a movement-based intervention twice per week for the course of 8 weeks. The intervention will be structured in 45 minutes sessions and divided in stations focused on fundamental motor skills.

- The goal each week will be to participate at least once in each station (it is expected that this goal will take time for some of the children to reach- therefore we will work towards participating in each station through the course of the intervention).

Stations:
Object-control skills: This station will consist of a number of activities that involve balls and ball skills.

Equipment: Various balls including basketballs, soccer balls, tennis balls, playground balls and adapted balls (different sizes, weights and textures for age appropriateness), adapted footballs, bean bags, adapted bowling balls, plastic bowling pins, wall targets, pylons.
Activities: adapted games and activities focused on object control skills such as: throwing, catching, kicking, trapping, dribbling, striking and rolling.

Progression: Examples of progression will include introduction games and activities that are developmentally appropriate. For example, pass games will be initiated with balls of different sizes, weights and textures. Games will include passes involving different skills such as throwing, rolling, bouncing, kicking etc. The activities will be facilitated by the researcher but led by the parent/caregiver.

Gross motor skills: walking, running, galloping, leaping, hopping, jumping, skipping, climbing, sliding, etc.

Equipment: mats, low balance beam, poly spots, beanbags, tape (gym floor lines), pylons, etc.

Activities: Activities will be encouraged that allow the children to play with movement. Experimenting with different aspects of movement will be important for this station. For example walking will be encouraged using giant steps, small steps, sideway steps, side crossover steps, backward walking, pivoting, crab walking, rocking horse, elephant walking, etc. Activities for this station will also encourage playing with movement. Common movement activities will be used, such as Simon says, Red-light green light, Chase, What time is it Mr. Wolf, Follow-the-leader, etc (activities will be based on developmental appropriateness during the intervention).

Progression: Free play will be introduced to encourage various levels of movement skills (ie/ chase using different skills or follow the leader using various walking patterns). Games and activities (such as those indicated above) will be introduced when children begin to engage in the skills or new levels of a skill. The researcher will introduce different levels of an activity and then help the parent to teach different levels of the movement (ie. Different walking patterns).

Fine motor skills: grasping, drawing (tracing), writing, coloring, buttoning, stacking blocks, building, and object manipulation (including activities that required visual motor control), hand-eye coordination.

Activities: This station will include activities that incorporate fine motor skills. Common activities and toys which encourage the use of these skills include, but are not limited too, building blocks, crayons, paper, markers, miniatures (small toy figurines), painting tables including finger paints.

Play & motor skills: Parachute games and other unique, common movement based activities will be introduced when the children are comfortable with the movement activities.

The intervention will be based on the parent-child dyad, however the intervention will take place with one or multiple parent-child dyads in one session. The focus of the intervention will be on learning motor skills.

- Control group: No intervention

vi) As soon as possible post-intervention assessments will be administered to the participants with autism (this will be attempted within one-week following the intervention). Assessments for the control group will take place approximately 8 weeks following baseline assessments. For a more in depth description of the assessments please see above.

- ADOS
- Mullen™ (or DAS-II as indicated through assessment descriptions)
- PDMS-2
- Video-1
- Video-2

Physical activity assessment using an accelerometer

vii) 2-months post intervention the following assessments will take place for participants with autism. Control assessments will take place 2-months following the second round of assessments (for a full description of assessment please see above).

- ADOS
- Mullen™ (or DAS-II as indicated through assessment descriptions)
- PDMS-2
- Video-1
- Video-2
- Physical activity assessment using an accelerometer

viii) It is expected that participants will be enrolled in this study for 4-6 months. This timeframe includes initial baseline assessments, intervention, and post intervention assessments- it also allows for occasional wait times in-between intervention and assessment.

- Statistical analysis and interpretation of data

  It is expected that the effect of this intervention will be assessed using a repeated-measures ANOVA with a priori contrasts that compare baseline with immediate post- and 2-month post- intervention outcome measures.

  Primary outcome measures by category include:

  Motor: PDMS-2 (Video 2- secondary outcome)

  Social: Calibrated autism severity scores, obtained through algorithms of raw ADOS scores (Video 1- secondary outcome)

  Physical activity: accelerometry

In all aspects of this research study the parents/ caregivers are present with their child participant. The research team will talk to the parent/ caregiver in instances where the behavior of the child indicates any sign of stress or emotions that might indicate their unwillingness to participate. Appropriate actions will be taken including but not limited to, the participants withdrawal from the study, the participants withdrawal from an activity (assessment) within the study and the child participants need for a break (ie/ snack, a bathroom break, a "play" break, etc).

A summary of the assessment results will be given to the parents/ caregivers. In most cases this includes age-equivalent scores and percentiles for the Mullen and PDMS-2. For the purpose of the ADOS, a summary of the behaviors will be indicated, for example behaviors where the child excels will be indicated (ie. "Excellent eye contact was made with the examiner during free play". Although the ADOS is a clinical tool to help with autism diagnosis the researchers administering this tool are not clinicians. Should a child without autism meet criteria for autism based on our assessment a descriptive summary of the behaviors seen in the assessment will still be sent home (ie. "your child displayed descriptive gestures during the demonstration task but displayed fewer gestures than we would have expected during the course of the assessment). A diagnostic code will not be indicated.

It is likely that children without autism will display some characteristics that children with autism display. However, the scoring of this diagnostic tool is based on strict behavioral coding thresholds and this information will not be included in the parent summaries. If a child displays characteristics that are consistent with an autism diagnosis, the research will inform the parents verbally, in person or by phone. However, it will be clearly stated that this diagnostic tool, is a tool with a reliability of about 70% when it is used in combination with other tools. Therefore, a formal assessment by a clinician is needed for a more in depth, formal diagnosis. Please see the attached exemplar of an assessment summary.

17. Compensation: N/A
18. Cost: N/A
19. Anonymity or Confidentiality
    - All identifiable information will be kept in a locked room in a locked file cabinet. Participants will be assigned an identification number (ID number), which will be linked to their respective data. Therefore, participant names will not appear within the electronic dataset. Any (and few) documents linking the participant ID number and the participant name will be locked and filed. Any electronic document with the participant name and ID number will be kept in a secured file, which will be password protected- no data will be linked to this file.
    - Identifiable data such as consent forms; demographic questionnaires, etc will be stored in a locked file cabinet- electronic versions of this data will only include participant ID.
    - Videos for this study will be kept on a secured server and/or a secured external hard drive (a secured hard drive will stored in a locked cabinet when it is not in use).
    - The participant ID number will be linked with consent documents- this process will be employed as a back-up to insure that data is usable should an electronic malfunction occur.
    - One electronic document will also exist with participant ID numbers and names- this document will be password protected. Regular contact is needed with the families and this document will aid in keeping track of intervention/ assessment timelines. For example, if participant #1 is scheduled for an assessment, this electronic file will allow quick reference for participants names and contact in order for the research team to remind them of their scheduled research appointment, etc.
    - Data from this study will be kept indefinitely. Autism Spectrum Disorder is quickly becoming a public health concern. Currently, the best mode of treatment for young children with autism is early intervention. Unfortunately, assessments-

whether developmental or motor-based have been standardized with typically developed children. The play-based and motor-based video assessments are allowed for direct behavior observation and are critical in capturing change through research (based on intervention). In this study, identifiable data will be kept indefinitely and used for future research when parents have indicated their consent for this in the consent document. If parents do not consent to using their data and their child's data in subsequent research studies identifiable data will be destroyed or "deleted" when the results from this study have been fully completed.

- Parents have the option of being photographed and/or videotaped during this research for media publication and conference presentations. If parents agree to this option they will always be informed when a photograph or video is being taken for the presentation or for a media publication. They always have the right to withdraw this optional consent. If the media is present when an optional consent has been agreed to Parents will always be informed. This optional consent will be carefully monitored.

20. Risks

- This study is expected to have no more than minimal risk to the participants. These minimal risks include:
  Although the child participants are participating in assessments and physical activities, it is expected that the risks associated with these play-based assessments and the physical activity intervention pose no more risks than typical scratches or bruises that children may experience in traditional play. Most of the assessments in this study have been standardized for young children in this age-range and are commonly administered to young children with autism.

Minimizing Risks:

In all aspects of this research study the parents/ caregivers are present with their child participant. The research team will talk to the parent/ caregiver in instances where the behavior of the child indicates any sign of stress or emotions that might indicate their unwillingness to participate. Appropriate actions will be taken including but not limited to, the participants withdrawal from the study, the participants withdrawal from an activity (assessment) within the study and the child participants need for a break (ie/ snack, a bathroom break, a "play" break, etc).

Other Potential Risks:

Breach of Confidentiality: There is a risk that we could accidentally disclose information that identifies the participant.

Movement Groups: We will ask all participants to maintain confidentiality. However, there is still a risk that participants may be identified by other group members outside of the group.

Unforeseeable risks: There may be side effects from the study procedures that are not yet known to the researchers.

email: The security and confidentiality of information sent by email cannot be guaranteed. Information sent by email can be intercepted, corrupted, lost, destroyed, arrive late or incomplete, or contain viruses.

All study team members are trained in working with human subjects and the study team will make all efforts to ensure that the risks outlined do not occur. Please refer to section 19 in regards to how data will be handled to ensure confidentiality. The study team will explain to participants the importance of confidentiality beyond the treatment setting.

21. Benefits:
    - It is hypothesized that the experimental participants will benefit in the area of motor skills and social communicative skills through increased physical activity; yet, this study needs to be administered in order to fully understand whether or not these benefits exist.
22. Assessment of Risk: Benefit ratio: The benefits of participating in these assessments (control & experimental) and intervention (experimental) outweigh the minimal risk association with this study.
23. Mandatory Reporting:
    Under Oregon law, researchers are required to report to the appropriate authorities any information concerning child or elder abuse or neglect. The researchers may also report threats of harm to self or to others. In instances where study team member suspect abuse they will contact the appropriate authorities, most likely social services.

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Appendix B: Supplemental Information Form

SUPPLEMENTAL INFORMATION

1. Child's name____
2. Parent's name/ relationship: ____
3. Parent's name/ relationship: ____
4. Child's birth date___________________
5. Child's due date ___________________
6. Birth Weight________________
7. Age in months of walking (5 steps):____________
8. Age in months sitting: ________________________
9. Have your child been diagnosed with autism (circle one)? Yes No
10. How much early intervention has the child received?
    ____
    ____
    ____
    ____
    ____
11. Does your child have any other disabilities (i.e. ADHD, asthma, etc.)?
    ____
    ____
    ____
    ____
    ____
12. Medications the child is currently taking:
    ____
    ______
13. Child's race: ___African American ___Hispanic ___Caucasian
    ___Asian American ___Mixed descent
    _____________________Other (please specify)

14. The number of siblings the child has and the child's birth order:
# of siblings:________ birth order:_________

15. Age of parents at the child's birth:
Mother:_______
Father:________

16. Parent's highest level of education:
Mother:_________________________
Father:__________________________

17. Estimated Annual Family Income (optional):
___________ under $20,000
___________ $20,000-40,000
___________ $40,000-60,000
___________ $60,000-80,000
___________ $80,000-100,000
___________ over $100,000